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CLINICAL INVESTIGATIONS

Trends in hospitalization for congestive heart failure, 1996–2009

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Background: Although heart failure (HF) is a common cause of hospital admissions, few data describe temporal trends in HF hospitalization. We present data on number of HF admissions, length of stay (LOS), and inpatient mortality in the United States, 1996–2009.

Hypothesis: To assess HF hospitalizations in a national sample of United States population.

Methods: Data were obtained from the National Hospital Discharge Survey (NHDS), a national probability sample survey of discharges conducted annually by the National Center for Health Statistics. Sampling weights are applied to raw NHDS data to produce national estimates. Hospitalizations with a primary diagnosis of HF were identified using ICD-9-CM codes. We excluded hospitalizations where HF was a secondary diagnosis. Weighted least squares regression was used to test for linear trends in HF hospitalizations.

Results: Approximately 15.5 million weighted primary HF hospitalizations were included. The number of total primary HF hospitalizations increased from 1 000 766 in 1996 to about 1 173 832 in 2009 (β = 7371 hospitalizations per year; 95% confidence interval (CI): 552 to 14 190, P = 0.036). Mean LOS per hospitalization decreased from 6.07 days in 1996 to about 5.26 days in 2009 (β = −0.059 days per year; 95% CI: −0.079 to −0.039, P < 0.001). Inpatient mortality rates declined from 4.92% in 1996 to 3.41% in 2009 (β = −0.17% per year; 95% CI: −0.23 to −0.10, P < 0.001).

Conclusions: In a nationally representative sample of HF hospitalizations, mean LOS and inpatient mortality rates declined over the past 2 decades. HF management cost is most likely to be reduced by decreasing the number of HF admissions.

KEYWORDS

Heart failure/cardiac transplantation/cardiomyopathy/myocarditis, Admissions, Mortality

1 | INTRODUCTION

Heart failure (HF) is a common cause of morbidity and mortality.[1] The prevalence of HF is increasing in the United States due to an aging population and to significant advances in management of associated comorbidities such as ischemic heart disease, diabetes mellitus, stroke, peripheral vascular disease, and hypertension.[2,3] Currently, >5 million Americans are living with HF and 0.5 million patients are newly diagnosed with HF every year.[1]

HF is also a leading cause of hospital admissions, with significant healthcare costs driven by the acuity of care and hospital length of stay (LOS).[4] A report from the American Heart Association Statistics Committee estimates the annual direct and indirect costs associated with HF in the United States at > $30.7 billion.[5] However, little is known about recent temporal trends in the number of HF hospital admissions, LOS, and in-hospital mortality in the United States. We therefore analyzed an open-access national probability sample survey of discharges to examine these parameters.

2 | METHODS

2.1 | Data source

For the purpose of our study, we extracted data from National Hospital Discharge Survey (NHDS). The NHDS was initiated by National

TABLE 1 Patient demographics and clinical characteristics

	1996	1997	1998	1999	2000
Age, y, median (IQR)	74.9 (65.7–82.4)	74.9 (65.5–82.5)	75.1 (65.6–82.4)	75.6 (65.7–82.8)	74.7 (64.7–82.2)
Sex					
M	426 986 (42.7)	486 700 (44.9)	480 649 (43.7)	474 932 (43.6)	460 471 (41.7)
F	573 780 (57.3)	597 732 (55.1)	619 993 (56.3)	613 828 (56.4)	643 535 (58.3)
Race					
White	655 328 (65.5)	716 093 (66.0)	702 277 (63.8)	704 881 (64.7)	659 059 (59.7)
Black	148 274 (14.8)	147 254 (13.6)	158 064 (14.4)	161 088 (14.8)	164 811 (14.9)
Other/not stated	197 164 (19.7)	221 085 (20.4)	240 301 (21.8)	222 791 (20.5)	280 136 (25.4)
Marital status					
Married	275 526 (27.5)	318 087 (29.3)	293 397 (26.7)	298 646 (27.4)	293 134 (26.6)
Single	85 267 (8.5)	102 898 (9.5)	89 440 (8.1)	94 684 (8.7)	96 403 (8.7)
Widowed	254 272 (25.4)	230 975 (21.3)	244 127 (22.2)	238 018 (21.9)	261 573 (23.7)
Divorced	28 740 (2.9)	31 793 (2.9)	46 201 (4.2)	36 907 (3.4)	51 220 (4.6)
Separated	5983 (0.6)	4162 (0.4)	3494 (0.3)	6823 (0.6)	4827 (0.4)
Not stated	350 978 (35.1)	396 517 (36.6)	423 983 (38.5)	413 682 (38.0)	396 849 (35.9)
Region					
Northeast	218 134 (21.8)	232 251 (21.4)	240 411 (21.8)	247 201 (22.7)	261 139 (23.7)
Midwest	252 562 (25.2)	290 097 (26.8)	293 193 (26.6)	281 656 (25.9)	277 888 (25.2)
South	384 059 (38.4)	412 155 (38.0)	413 578 (37.6)	417 411 (38.3)	427 944 (38.8)
West	146 011 (14.6)	149 929 (13.8)	153 460 (13.9)	142 492 (13.1)	137 035 (12.4)
Ischemic heart disease	388 038 (38.8)	416 708 (38.4)	444 930 (40.4)	432 486 (39.7)	441 961 (40.0)
Ventricular arrhythmias	42 420 (4.2)	50 396 (4.6)	38 628 (3.5)	42 496 (3.9)	43 414 (3.9)
LBBB	24 617 (2.5)	28 553 (2.6)	21 830 (2.0)	22 912 (2.1)	21 527 (1.9)
Complete AV block	6364 (0.6)	4159 (0.4)	5562 (0.5)	2620 (0.2)	3986 (0.4)
AF	237 165 (23.7)	276 648 (25.5)	274 973 (25.0)	263 971 (24.2)	258 715 (23.4)
PVD	61 312 (6.1)	56 945 (5.3)	70 732 (6.4)	51 617 (4.7)	57 947 (5.2)
HTN	246 838 (24.7)	280 737 (25.9)	300 960 (27.3)	326 656 (30.0)	347 599 (31.5)
Chronic pulmonary diseases	250 517 (25.0)	302 357 (27.9)	313 733 (28.5)	308 082 (28.3)	312 959 (28.3)
DM	322 477 (32.2)	326 441 (30.1)	367 210 (33.4)	362 112 (33.3)	390 804 (35.4)
CKD	66 546 (6.6)	70 896 (6.5)	79 122 (7.2)	77 972 (7.2)	83 286 (7.5)
Anemia	92 001 (9.2)	98 362 (9.1)	109 451 (9.9)	122 718 (11.3)	121 193 (11.0)
Pulmonary circulation disorders	31 649 (3.2)	45 842 (4.2)	48 299 (4.4)	51 747 (4.8)	56 233 (5.1)
Paralysis	13 230 (1.3)	12 569 (1.2)	15 614 (1.4)	14 229 (1.3)	11 191 (1.0)
Valvular diseases	172 431 (17.2)	208 045 (19.2)	196 090 (17.8)	194 174 (17.8)	177 889 (16.1)
Other neurologic disorders	29 918 (3.0)	32 668 (3.0)	36 016 (3.3)	34 961 (3.2)	30 197 (2.7)
Hypothyroidism	64 049 (6.4)	63 151 (5.8)	61 766 (5.6)	76 878 (7.1)	81 037 (7.3)
Liver disease	10 483 (1.0)	12 039 (1.1)	11 579 (1.1)	7404 (0.7)	9571 (0.9)
Peptic ulcer disease	12 650 (1.3)	11 589 (1.1)	11 815 (1.1)	12 694 (1.2)	11 157 (1.0)
HIV/AIDS	1666 (0.2)	1584 (0.1)	1272 (0.1)	1073 (0.1)	975 (0.1)
Lymphoma	9779 (1.0)	6043 (0.6)	5226 (0.5)	7077 (0.7)	7771 (0.7)
Metastatic cancer	7654 (0.8)	10 734 (1.0)	9000 (0.8)	9368 (0.9)	8540 (0.8)
Solid tumor without metastasis	44 427 (4.4)	52 161 (4.8)	62 893 (5.7)	51 492 (4.7)	45 574 (4.1)
Collagen vascular diseases	12 232 (1.2)	18 817 (1.7)	14 958 (1.4)	16 745 (1.5)	13 050 (1.2)
Coagulopathy	14 444 (1.4)	17 716 (1.6)	15 510 (1.4)	16 299 (1.5)	17 216 (1.6)
Obesity	33 451 (3.3)	39 315 (3.6)	38 339 (3.5)	45 218 (4.2)	40 243 (3.6)
Weight loss	10 871 (1.1)	16 827 (1.6)	13 020 (1.2)	11 535 (1.1)	11 295 (1.0)

TABLE 1 Continued

	1996	1997	1998	1999	2000
Fluid and electrolyte disorders	150 925 (15.1)	165 753 (15.3)	163 796 (14.9)	149 149 (13.7)	165 933 (15.0)
Alcohol abuse	15 702 (1.6)	15 969 (1.5)	11 149 (1.0)	15 469 (1.4)	18 029 (1.6)
Drug abuse	5272 (0.5)	7242 (0.7)	7981 (0.7)	5811 (0.5)	8561 (0.8)
Depression	21 305 (2.1)	24 631 (2.3)	24 177 (2.2)	36 557 (3.4)	31 918 (2.9)
Psychosis	10 054 (1.0)	13 205 (1.2)	14 423 (1.3)	15 813 (1.5)	12 678 (1.1)
	2001	**2002**	**2003**	**2004**	**2005**
Age, y, median (IQR)	75.3 (64.6–82.8)	74.3 (62.7–82.6)	74.3 (62.6–82.6)	75.4 (63.7–82.7)	74.8 (63.1–83.2)
Sex					
M	485 455 (44.6)	485 963 (44.8)	535 006 (45.2)	558 821 (47.4)	522 525 (45.1)
F	601 878 (55.4)	597 612 (55.2)	648 576 (54.8)	621 038 (52.6)	634 863 (54.9)
Race					
White	682 977 (62.8)	674 252 (62.2)	738 312 (62.4)	708 242 (60.0)	721 745 (62.4)
Black	153 640 (14.1)	170 356 (15.7)	181 723 (15.4)	174 274 (14.8)	180 479 (15.6)
Other/not stated	250 716 (23.1)	238 967 (22.1)	263 547 (22.3)	297 343 (25.2)	255 164 (22.0)
Marital status					
Married	300 593 (27.6)	320 733 (29.6)	319 570 (27.0)	290 746 (24.6)	285 137 (24.6)
Single	99 150 (9.1)	108 422 (10.0)	128 949 (10.9)	129 277 (11.0)	106 542 (9.2)
Widowed	229 102 (21.1)	221 626 (20.5)	263 808 (22.3)	242 549 (20.6)	239 441 (20.7)
Divorced	48 645 (4.5)	56 959 (5.3)	47 104 (4.0)	43 793 (3.7)	57 924 (5.0)
Separated	9054 (0.8)	8563 (0.8)	7520 (0.6)	8015 (0.7)	6612 (0.6)
Not stated	400 789 (36.9)	367 272 (33.9)	416 631 (35.2)	465 479 (39.5)	461 732 (39.9)
Region					
Northeast	258 848 (23.8)	246 772 (22.8)	257 867 (21.8)	261 314 (22.1)	257 125 (22.2)
Midwest	292 696 (26.9)	256 018 (23.6)	294 125 (24.9)	302 242 (25.6)	292 384 (25.3)
South	390 630 (35.9)	414 322 (38.2)	472 105 (39.9)	449 910 (38.1)	439 594 (38.0)
West	145 159 (13.4)	166 463 (15.4)	159 485 (13.5)	166 393 (14.1)	168 285 (14.5)
Ischemic heart disease	439 637 (40.4)	433 266 (40.0)	451 095 (38.1)	458 849 (38.9)	419 956 (36.3)
Ventricular arrhythmias	35 107 (3.2)	43 195 (4.0)	49 564 (4.2)	57 382 (4.9)	58 369 (5.0)
LBBB	16 935 (1.6)	20 838 (1.9)	21 430 (1.8)	20 713 (1.8)	25 746 (2.2)
Complete AV block	1961 (0.2)	3630 (0.3)	2089 (0.2)	3230 (0.3)	5210 (0.5)
AF	295 464 (27.2)	291 604 (26.9)	327 393 (27.7)	348 584 (29.5)	341 676 (29.5)
PVD	61 635 (5.7)	59 590 (5.5)	55 928 (4.7)	59 865 (5.1)	53 678 (4.6)
HTN	353 689 (32.5)	366 217 (33.8)	397 512 (33.6)	386 976 (32.8)	383 836 (33.2)
Chronic pulmonary diseases	318 394 (29.3)	305 453 (28.2)	363 921 (30.7)	355 064 (30.1)	346 683 (30.0)
DM	380 496 (35.0)	378 459 (34.9)	408 382 (34.5)	385 513 (32.7)	358 570 (31.0)
CKD	97 592 (9.0)	97 294 (9.0)	139 078 (11.8)	138 006 (11.7)	154 535 (13.4)
Anemia	114 848 (10.6)	132 615 (12.2)	136 948 (11.6)	145 903 (12.4)	129 409 (11.2)
Pulmonary circulation disorders	57 096 (5.3)	54 581 (5.0)	59 988 (5.1)	51 508 (4.4)	55 283 (4.8)
Paralysis	14 783 (1.4)	12 980 (1.2)	13 897 (1.2)	8713 (0.7)	11 952 (1.0)
Valvular diseases	188 758 (17.4)	194 495 (17.9)	190 826 (16.1)	210 015 (17.8)	211 345 (18.3)
Other neurologic disorders	32 933 (3.0)	32 653 (3.0)	41 324 (3.5)	32 125 (2.7)	38 224 (3.3)
Hypothyroidism	80 422 (7.4)	79 048 (7.3)	87 631 (7.4)	79 869 (6.8)	84 083 (7.3)
Liver disease	12 619 (1.2)	13 489 (1.2)	26 140 (2.2)	17 372 (1.5)	18 354 (1.6)
Peptic ulcer disease	10 437 (1.0)	7958 (0.7)	4868 (0.4)	6592 (0.6)	5509 (0.5)
HIV/AIDS	1601 (0.1)	738 (0.1)	4726 (0.4)	1135 (0.1)	1766 (0.2)
Lymphoma	10 320 (0.9)	5905 (0.5)	5284 (0.4)	8605 (0.7)	11 431 (1.0)
Metastatic cancer	8392 (0.8)	10 716 (1.0)	10 979 (0.9)	8207 (0.7)	11 576 (1.0)

TABLE 1 Continued

	2001	2002	2003	2004	2005
Solid tumor without metastasis	46 228 (4.3)	49 618 (4.6)	49 111 (4.1)	42 827 (3.6)	40 598 (3.5)
Collagen vascular diseases	13 205 (1.2)	15 860 (1.5)	14 260 (1.2)	13 344 (1.1)	19 629 (1.7)
Coagulopathy	19 268 (1.8)	20 606 (1.9)	20 596 (1.7)	26 452 (2.2)	29 191 (2.5)
Obesity	49 963 (4.6)	60 442 (5.6)	60 904 (5.1)	62 667 (5.3)	56 390 (4.9)
Weight loss	7400 (0.7)	10 425 (1.0)	13 921 (1.2)	12 825 (1.1)	10 448 (0.9)
Fluid and electrolyte disorders	163 463 (15.0)	167 207 (15.4)	184 279 (15.6)	189 034 (16.0)	178 292 (15.4)
Alcohol abuse	15 872 (1.5)	18 434 (1.7)	16 549 (1.4)	23 886 (2.0)	21 097 (1.8)
Drug abuse	7380 (0.7)	13 237 (1.2)	11 761 (1.0)	13 490 (1.1)	20 374 (1.8)
Depression	35 496 (3.3)	35 328 (3.3)	48 511 (4.1)	44 837 (3.8)	40 524 (3.5)
Psychosis	8933 (0.8)	16 061 (1.5)	19 062 (1.6)	17 723 (1.5)	15 454 (1.3)
Smoking (other tobacco use)	37 289 (3.4)	54 252 (5.0)	51 221 (4.3)	46 932 (4.0)	65 236 (5.6)

	2006	2007	2008	2009	*P* Value
Age, y, median (IQR)	75.4 (62.3–83.7)	74.7 (61.9–82.8)	74.8 (62.5–83.8)	74.3 (61.5–83.6)	<0.0001
Sex					<0.0001
M	553 924 (46.8)	502 366 (47.6)	527 265 (47.8)	568 185 (48.4)	
F	629 108 (53.2)	554 008 (52.4)	575 181 (52.2)	605 647 (51.6)	
Race					<0.0001
White	729 451 (61.7)	620 008 (58.7)	623 992 (56.6)	738 526 (62.9)	
Black	191 124 (16.2)	183 120 (17.3)	212 400 (19.3)	219 528 (18.7)	
Other/not stated	262 457 (22.2)	253 246 (24.0)	266 054 (24.1)	215 778 (18.4)	
Marital status					<0.0001
Married	310 516 (26.2)	259 426 (24.6)	245 274 (22.2)	278 232 (23.7)	
Single	136 307 (11.5)	131 030 (12.4)	130 501 (11.8)	130 970 (11.2)	
Widowed	252 791 (21.4)	205 712 (19.5)	231 811 (21.0)	206 028 (17.6)	
Divorced	53 343 (4.5)	44 868 (4.2)	45 123 (4.1)	56 355 (4.8)	
Separated	9511 (0.8)	4618 (0.4)	6214 (0.6)	8364 (0.7)	
Not stated	420 564 (35.5)	410 720 (38.9)	443 523 (40.2)	493 883 (42.1)	
Region					0.005
Northeast	266 656 (22.5)	231 963 (22.0)	274 295 (24.9)	249 321 (21.2)	
Midwest	302 149 (25.5)	265 088 (25.1)	247 054 (22.4)	282 149 (24.0)	
South	445 357 (37.6)	397 225 (37.6)	436 605 (39.6)	468 276 (39.9)	
West	168 870 (14.3)	162 098 (15.3)	144 492 (13.1)	174 086 (14.8)	
Ischemic heart disease	423 172 (35.8)	347 371 (32.9)	356 414 (32.3)	340 865 (29.0)	<0.0001
Ventricular arrhythmias	64 251 (5.4)	46 447 (4.4)	54 349 (4.9)	45 422 (3.9)	0.001
LBBB	20 504 (1.7)	15 236 (1.4)	22 562 (2.0)	26 674 (2.3)	0.098
Complete AV block	5247 (0.4)	2329 (0.2)	3067 (0.3)	6705 (0.6)	0.048
AF	351 414 (29.7)	309 393 (29.3)	259 905 (23.6)	253 448 (21.6)	<0.0001
PVD	60 245 (5.1)	35 160 (3.3)	42 338 (3.8)	37 572 (3.2)	<0.0001
HTN	358 597 (30.3)	305 375 (28.9)	310 059 (28.1)	310 892 (26.5)	<0.0001
Chronic pulmonary diseases	370 091 (31.3)	298 346 (28.2)	267 117 (24.2)	286 982 (24.4)	<0.0001
DM	359 555 (30.4)	299 136 (28.3)	305 772 (27.7)	311 115 (26.5)	<0.0001
CKD	225 586 (19.1)	106 311 (10.1)	100 281 (9.1)	138 031 (11.8)	<0.0001
Anemia	120 808 (10.2)	111 296 (10.5)	110 174 (10.0)	113 215 (9.6)	0.0002
Pulmonary circulation disorders	62 770 (5.3)	53 695 (5.1)	71 852 (6.5)	72 363 (6.2)	<0.0001
Paralysis	8772 (0.7)	9488 (0.9)	13 220 (1.2)	18 907 (1.6)	0.140
Valvular diseases	216 738 (18.3)	187 381 (17.7)	132 713 (12.0)	128 073 (10.9)	<0.0001
Other neurologic disorders	31 917 (2.7)	30 846 (2.9)	38 524 (3.5)	39 622 (3.4)	0.773
Hypothyroidism	80 934 (6.8)	55 316 (5.2)	69 359 (6.3)	59 687 (5.1)	0.0003

TABLE 1 Continued

	2006	2007	2008	2009	*P* Value
Liver disease	17 289 (1.5)	17 768 (1.7)	16 487 (1.5)	16 770 (1.4)	0.001
Peptic ulcer disease	3971 (0.3)	5817 (0.6)	4125 (0.4)	3266 (0.3)	<0.0001
HIV/AIDS	3554 (0.3)	1962 (0.2)	2184 (0.2)	1559 (0.1)	0.037
Lymphoma	7501 (0.6)	8677 (0.8)	9509 (0.9)	15 762 (1.3)	0.007
Metastatic cancer	9083 (0.8)	7462 (0.7)	11 227 (1.0)	6141 (0.5)	0.810
Solid tumor without metastasis	38 247 (3.2)	32 797 (3.1)	37 605 (3.4)	40 716 (3.5)	<0.0001
Collagen vascular diseases	14 856 (1.3)	13 869 (1.3)	10 551 (1.0)	12 345 (1.1)	0.282
Coagulopathy	27 419 (2.3)	23 403 (2.2)	14 081 (1.3)	27 666 (2.4)	0.0002
Obesity	54 451 (4.6)	48 927 (4.6)	50 753 (4.6)	45 768 (3.9)	0.0002
Weight loss	12 805 (1.1)	12 301 (1.2)	18 161 (1.6)	26 837 (2.3)	<0.0001
Fluid and electrolyte disorders	189 016 (16.0)	179 641 (17.0)	164 333 (14.9)	190 592 (16.2)	0.228
Alcohol abuse	19 064 (1.6)	14 433 (1.4)	8872 (0.8)	10 261 (0.9)	0.0003
Drug abuse	22 936 (1.9)	19 644 (1.9)	20 137 (1.8)	12 526 (1.1)	<0.0001
Depression	34 748 (2.9)	28 219 (2.7)	22 898 (2.1)	25 075 (2.1)	<0.0001
Psychosis	20 252 (1.7)	16 492 (1.6)	14 662 (1.3)	19 851 (1.7)	0.119
Smoking (other tobacco use)	59 546 (5.0)	54 980 (5.2)	64 895 (5.9)	60 530 (5.2)	<0.0001

Abbreviations: AF, atrial fibrillation; AIDS, acquired immune deficiency syndrome; CKD, chronic kidney disease; DM, diabetes mellitus; F, female; HIV, human immunodeficiency virus; HTN, hypertension; IQR, interquartile range; LBBB, left bundle branch block; M, male; PVD, peripheral vascular disease.

Data are presented as n (%) unless otherwise indicated.

Center for Health Statistics in 1964, and since then it has been collecting data on approximately 1% of hospital discharges every year in United States. The source of data is US nonfederal hospitals represented in all 50 states and the District of Columbia. Only those hospitals that have >6 beds with LOS of <30 days are included. The discharge records were selected from sample hospitals using systematic random sampling. The medical abstract form and discharge summaries are primarily used for data abstraction. Because patients are not followed longitudinally, it is possible that an individual patient may have ≥1 hospital admissions in the dataset. Variables included basic demographics such as age, sex, race, and marital status. Other variables include LOS, discharge outcomes and disposition, primary and secondary discharge diagnoses, and information on inpatient procedures. Each discharge is weighted so it can be inflated to national estimates. For this study, we included data from 1996 to 2009.

2.2 | Study population

From the NHDS data, patients admitted with a primary diagnosis of HF were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. The following ICD-9 codes were used to identify HF patients: 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, and 428. Patients with secondary diagnosis of HF were excluded from this study. Comorbidities were obtained by applying relevant ICD-9 codes to secondary diagnoses. The need for institutional review board approval was waived due to de-identified patient records and public availability of NHDS data.

2.3 | Statistical analysis

Because of the survey design, sampling weights are applied to the raw NHDS data to produce national estimates. The estimation procedure has 3 basic components: inflation by reciprocals of the probabilities of sample selection, adjustment for nonresponse, and population weighting ratio adjustments.[6]

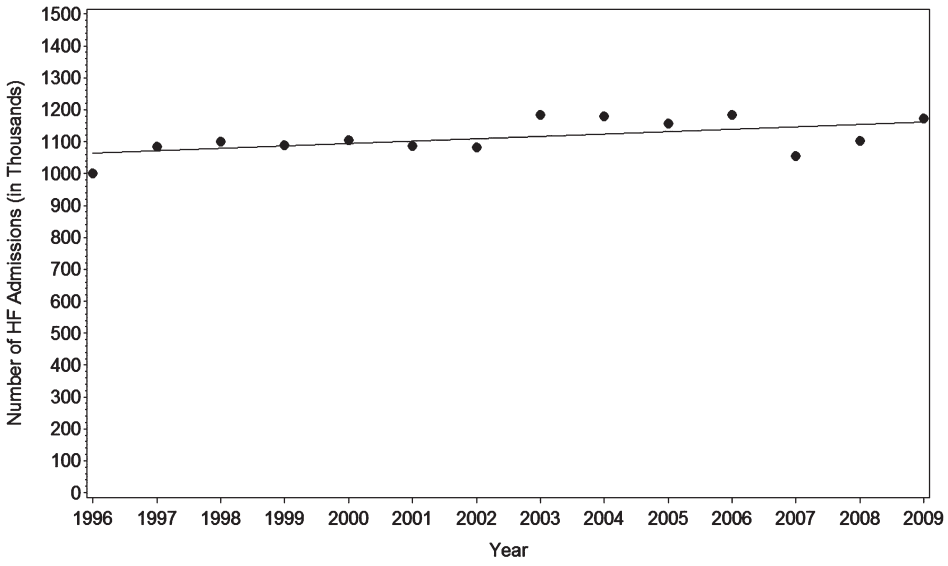
We report the estimated number of HF admissions, mean LOS, and inpatient mortality for each year from 1996 to 2009. Weighted least squares regression was used to test for linear trends in the number of HF admissions, LOS, and inpatient mortality. For each, we present the estimated annual change (β), along with a 95% confidence interval (CI) for β, and *P* value testing whether the slope of annual change of each parameter was significantly different from zero. We also studied hospitalization trends based on age groups, sex, and race. Data analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

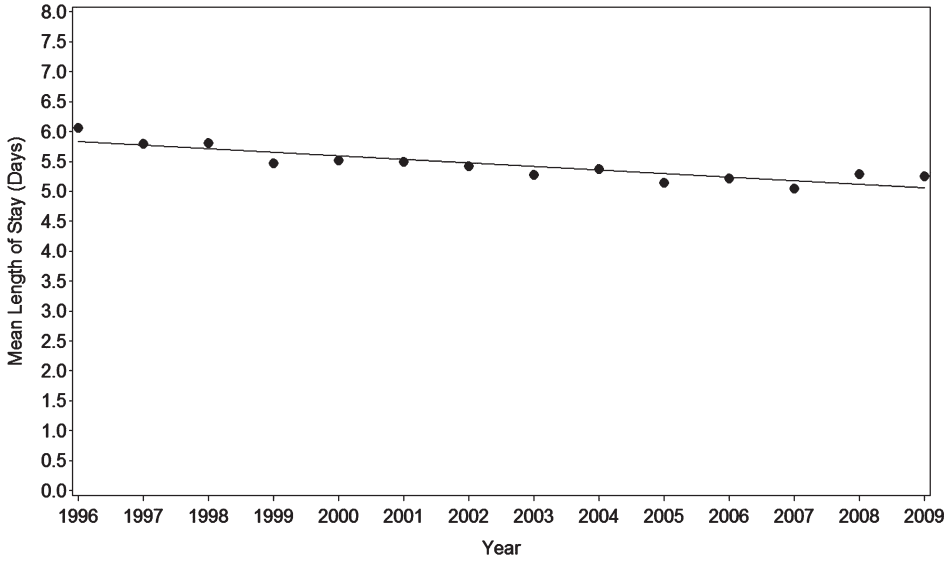
3 | RESULTS

The raw data contained a total of 125 672 primary HF hospitalizations, translating to an estimated 15.5 million HF hospitalizations from 1996 to 2009 after application of sample weights. The percentage of patients with selected other ICD-9 codes are presented in the Table 1.

3.1 | Number of HF admissions

The total number of hospitalizations with a primary diagnosis of HF increased over time (β = 7371 hospitalizations per year; 95% CI: 552 to 14 190, *P* = 0.036; Figure 1). The estimated number of HF hospitalizations rose from 1 000 766 in 1996 to about 1 173 832 in 2009. The increase in primary HF hospitalizations was uniform in both males and females (Figure 2). Similarly, a trend toward increased primary HF hospitalizations was also witnessed among different races (Figure 3) and also between various age groups (Figure 4).





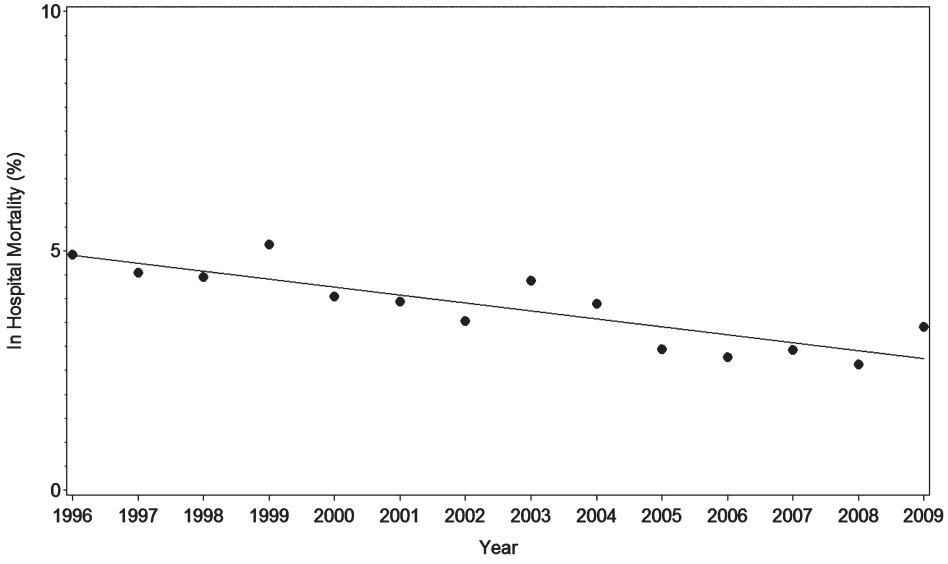


FIGURE 1 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; entire cohort. Abbreviations: HF, heart failure; LOS, length of stay.

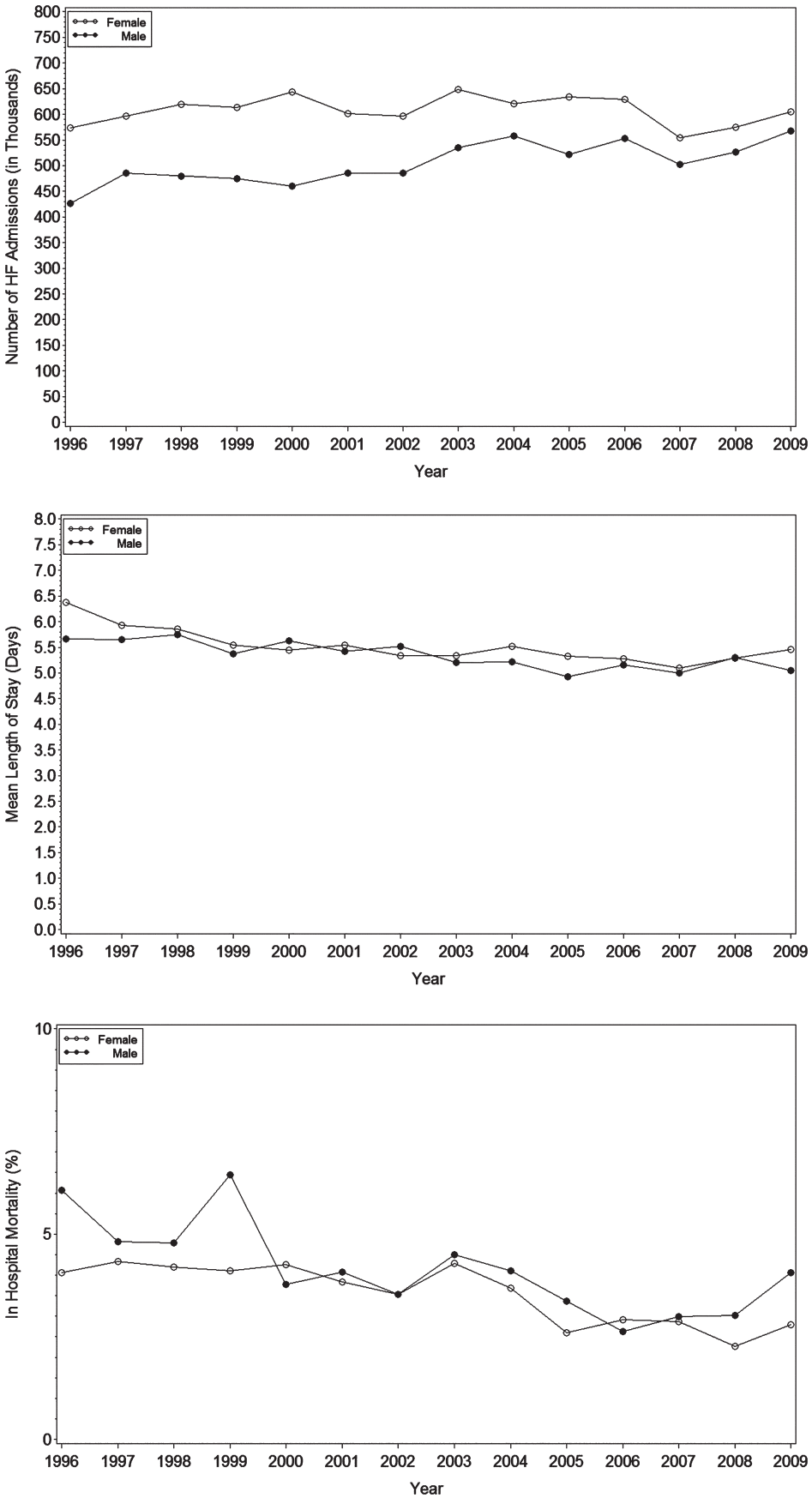
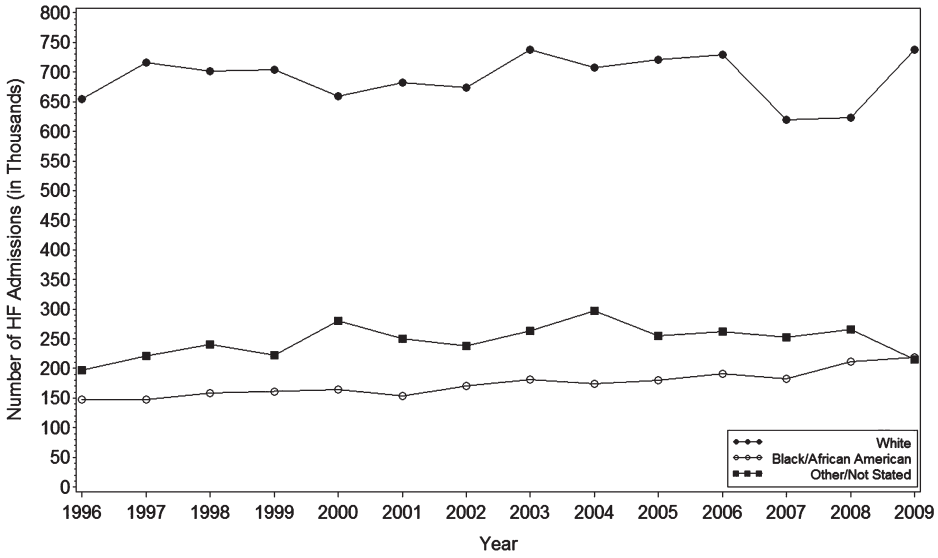
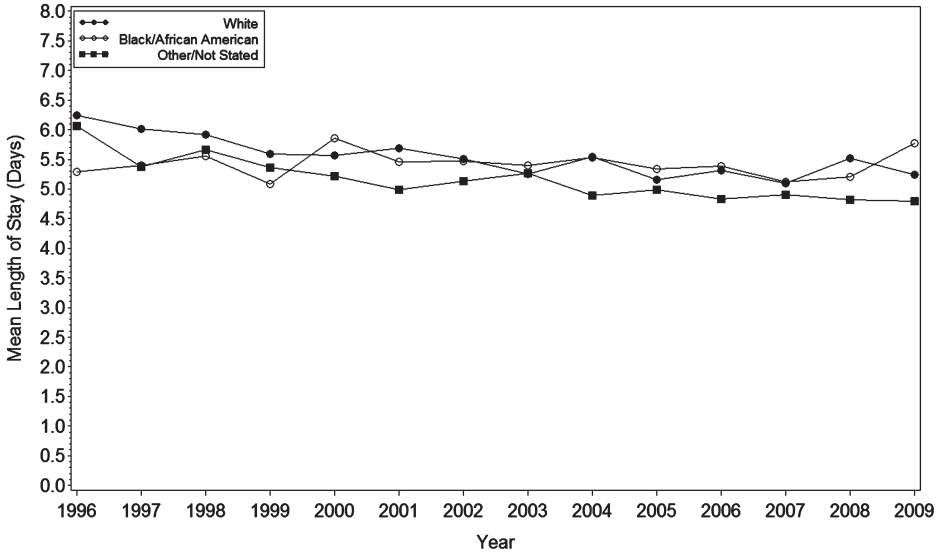


FIGURE 2 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by sex. Abbreviations: HF, heart failure; LOS, length of stay.





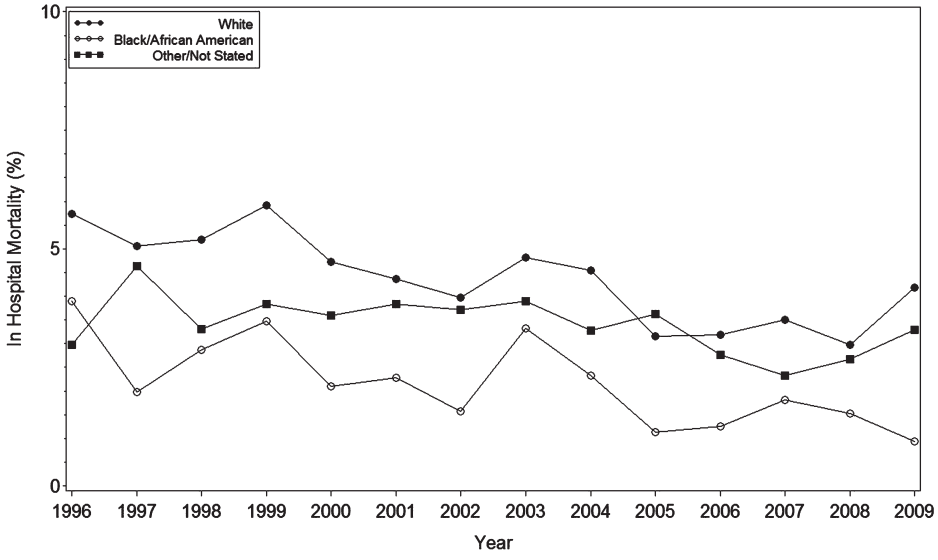
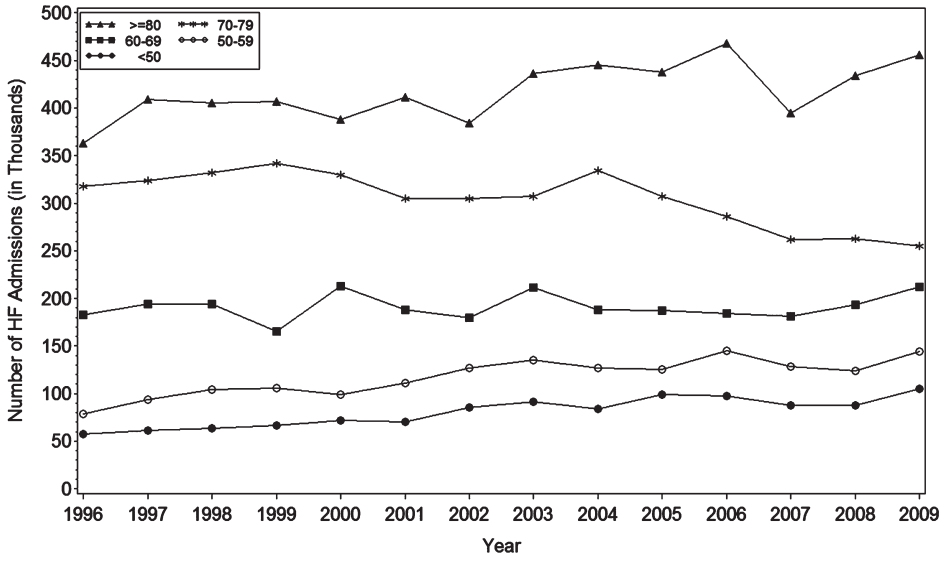
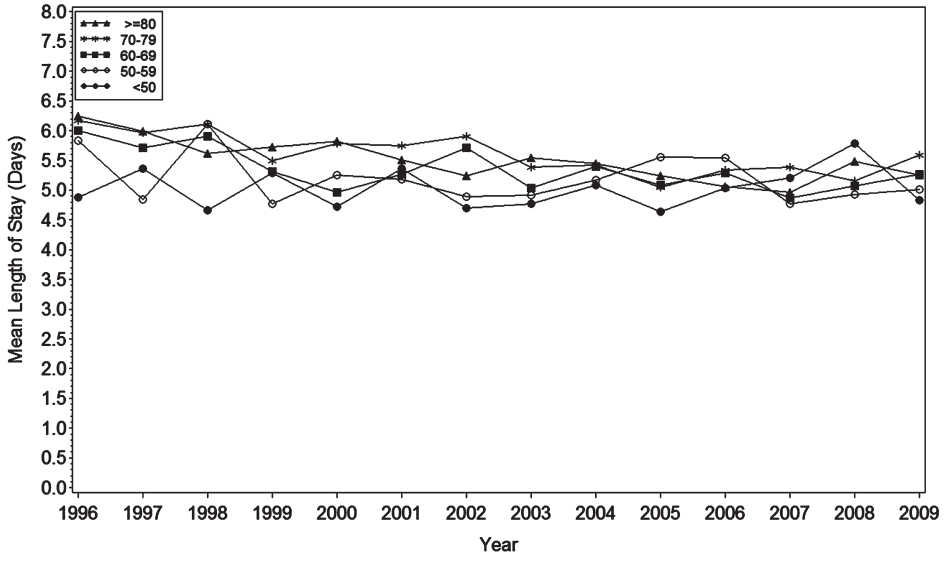


FIGURE 3 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by race. Abbreviations: HF, heart failure; LOS, length of stay.





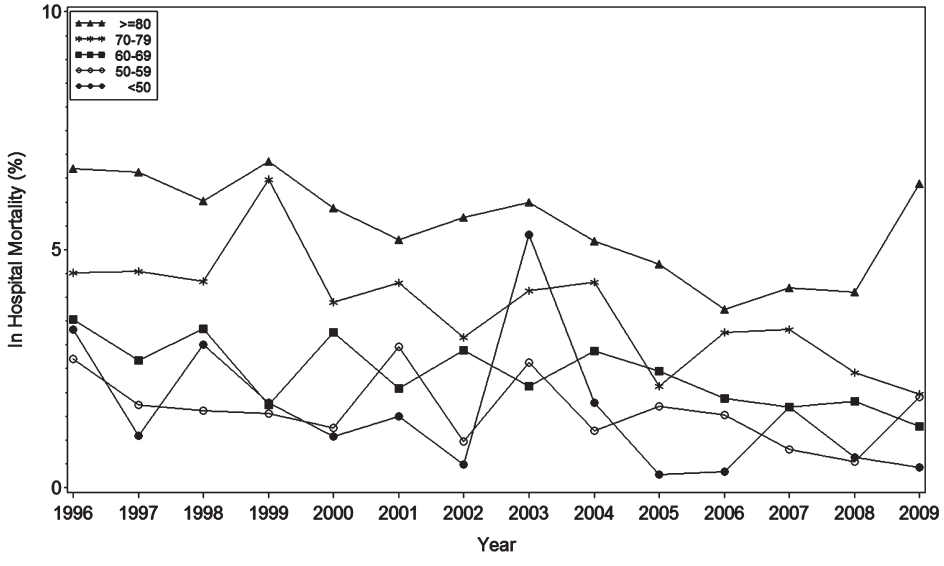


FIGURE 4 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by age. Abbreviations: HF, heart failure; LOS, length of stay.

3.2 | LOS in HF admissions

Mean LOS per HF hospitalization declined (β = −0.059 days per year; 95% CI: −0.079 to −0.039, $P < 0.001$; Figure 1). The estimated mean LOS per HF hospitalization decreased from 6.07 days in 1996 to about 5.26 days in 2009. Both sexes showed reduced LOS per primary HF hospitalization over the study period (Figure 2) as well. Similarly, mean LOS was 6.24 days among White Americans in 1996, which reduced to about 5.24 days in 2009 (Figure 3). African American patients were found to have slightly longer LOS, from 5.29 days in 1996 to 5.77 days in 2009 (Figure 3).

3.3 | Inpatient mortality in HF admissions

The percentage of primary HF hospitalizations ending with inpatient mortality decreased over time (β = −0.17% per year; 95% CI: −0.23 to −0.10, $P < 0.001$; Figure 1). The rate of inpatient mortality during HF hospitalization was 4.92% in 1996; it declined for several years with occasional spikes (1999 and 2003), reaching a nadir of 2.62% in 2008, before climbing slightly and ending at 3.41% in 2009. Inpatient mortality rates declined among both males and females over the study period (Figure 2), and a similar trend was observed among White and African American patients (Figure 3).

4 | DISCUSSION

In this large, nationally representative sample of hospitalizations in the United States, we document that over the past 2 decades, inpatient HF mortality and mean LOS have declined as the total number of hospitalizations with a primary diagnosis of HF has increased. These findings likely reflect changes in the management of HF in the United States and have important implications to the cost of managing this prevalent and morbid condition.

The past 2 decades have seen numerous advances in management of HF patients. Medical therapies for HF have progressed significantly over our study period, including drug therapies such as angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, and β-blockers, among others, as well as advanced HF options such as cardiac resynchronization therapy, ventricular assist devices, and heart transplantation.[7–11] In addition, quality-improvement initiatives have been and continue to be implemented to ensure proper adoption of these therapies.[12] This has resulted in improved HF survival and outcomes, as reflected in our study, albeit over the very short term.

Despite improvements in LOS and in-hospital mortality, the number of HF admissions continues to rise, in step with the increasing prevalence of HF.[1] This is likely a reflection of the fact that HF patients who benefit from advances in management options, many of which require or are traditionally applied in the inpatient setting, are living longer. In a previous study published in 2013, Blecker et al[13] analyzed hospitalizations for which HF was a primary or a secondary diagnosis and found a reduced incidence of primary HF hospitalizations but increased secondary HF hospitalizations in a cohort obtained from the Nationwide Inpatient Sample (NIS) database. Unlike the Blecker study, our present analysis focused exclusively on hospitalizations for which HF was the primary discharge diagnosis, thus excluding hospitalizations for other, often noncardiovascular, reasons in HF patients. By doing so, our analysis includes primarily hospital resource utilization patterns that can be directly attributed to HF, rather than to other conditions. In another study, Fang et al[14] found increased total HF hospitalizations from 1979 to 2004 in the United States, with reduction in LOS and inpatient mortality across those years. Our study has confirmed these predictions, although we have long follow-up (to 2009) and, as mentioned, our study has focused exclusively on primary HF hospitalizations. Using NIS data from 2001 to 2009, Chen et al[15] also found reduced LOS and inpatient mortality among primary HF hospitalizations. In comparison with our study, they found reduction in primary HF hospitalizations over their study timeframe; however, this reduction was only significant in elderly HF patients and was not demonstrated in younger patients admitted with primary HF diagnosis.

Our study shows increased prevalence of atrial fibrillation and depression over time in patients admitted with primary diagnosis of HF. Atrial fibrillation and depression have also been associated with more advanced symptoms of HF that require hospitalization.[16,17] These comorbid conditions may be the results of severe HF but could also contribute to worsening symptoms and decompensation. The explanations for these associations remain highly speculative and, unfortunately, cannot be examined through the NHDS data.

4.1 | Study limitations

In the NHDS data, HF is recognized by ICD-9 codes only; there is no other way to validate the diagnosis. ICD-9 codes are subject to change over time. We have, however, taken all ICD-9 codes into account that were prevalent during our study period. It may be possible that the few spikes in HF inpatient mortality that we identified, in 1999, 2003, and 2009, are due to admission of patients with advanced HF; however, our dataset does not describe the severity of HF for each patient. Furthermore, there is no rehospitalization data collected in NHDS, as patients are not longitudinally followed in this cohort, precluding analyses of readmission rates. In addition, the severity of HF symptoms or whether the admission is related to systolic or diastolic HF cannot be ascertained through the present dataset.

5 | CONCLUSION

Our report provides data on contemporary trends in HF hospitalizations using a nationally representative sample of the US population. There is an observed improvement in HF inpatient mortality and mean LOS, although we found an increase in the prevalence of HF admissions. Efforts to curtail the cost of HF management are therefore best directed at reducing the number of HF hospitalizations and readmissions, particularly for patients with less severe symptoms for whom aggressive outpatient management with remote home assistance may be sufficient.

Conflicts of interest

The authors declare no potential conflicts of interest.

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